Global Civil Aviation / Environmental Compatibility

Flight Test of Civil Tiltrotor Noise-Abatement Approach

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Civil tiltrotor transports have the potential to relieve the growing congestion around the Nation's conventional airport runways. Operating as regional transports, civil tiltrotors can operate from airport vertipads, from short, unused runway segments, or directly from urban vertiports located near population and business centers. Safe, all-weather, low-noise terminal-area operations are needed to realize the tiltrotor's potential for improving the capacity of the air transportation system. Rotorcraft noise, particularly that associated with approach operations, must be minimized to facilitate location of vertiports close to population centers.

As first demonstrated for helicopters with a NASA UH-60 flight test, complex, decelerating, noise-abatement approach profiles can be developed from previous fixed operating-point noise measurements. Precision approach guidance can then be developed, using satellite-based position data, and displayed to the pilot on a flight director. Application of this method to the tiltrotor includes proprotor nacelle angle as an additional approach control. Building upon tiltrotor instrument operations experience and flight director design developed in the Ames Vertical Motion Simulator, tiltrotor noise-abatement approach profiles and guidance were developed for flight test using the XV-15 aircraft.

A test team composed of NASA (Ames and Langley Centers), Army, and Bell Helicopter Textron personnel developed 20 approach profiles, guided by a programmable flight director using differential global positioning satellite tracking data, and measured the resulting noise ground footprint. An approach profile, described by the altitude track, airspeed, and nacelle angle, and the resulting ground footprint of the noise for a segmented noise-abatement approach, is shown in the figure. The

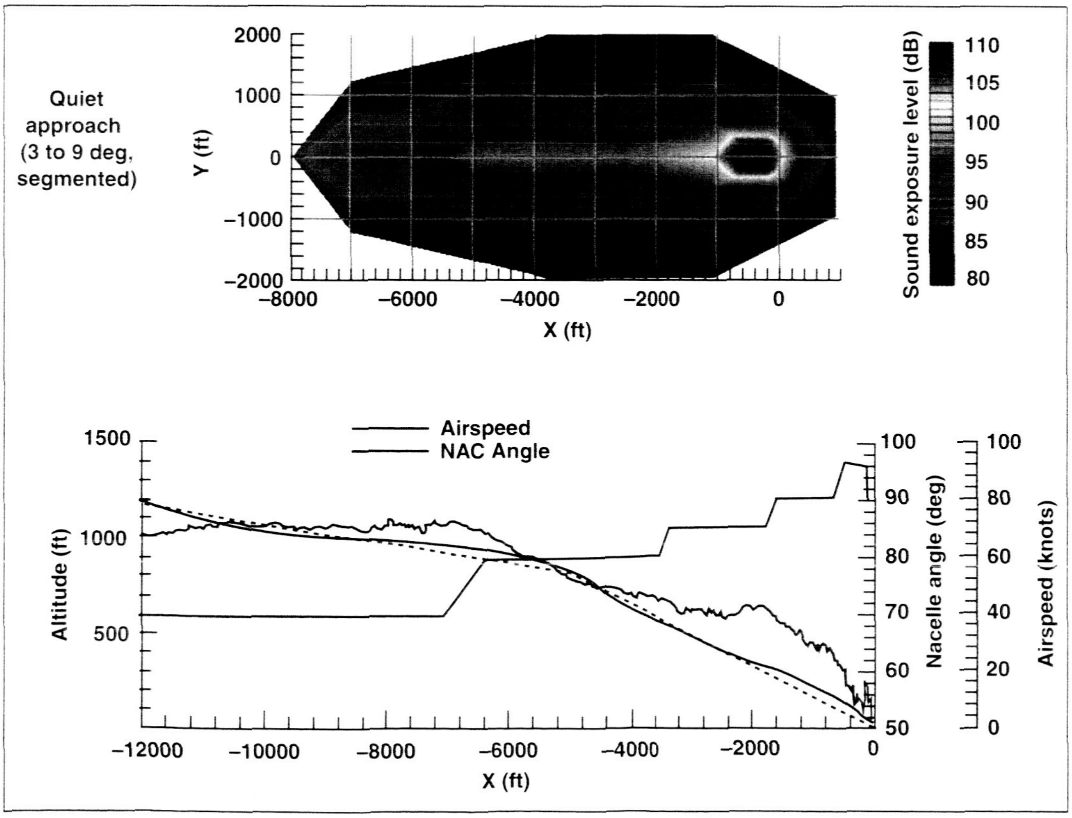

Fig. 1. Noise footprint (above) and approach profile track (below) for tiltrotor noise-abatement approach. The most intense noise is concentrated immediately around the hover pad.

approach profile and tracking are shown from 12,000 feet out from the hover pad. The ground microphone array for the noise footprint extended 8000 feet uprange from the hover pad and 1000 feet beyond. In the figure, the approach track shows the desired height-distance profile as a dashed line, with the actual position track shown as a solid line around it. Airspeed began at 70 knots. Decelerations are initiated by moving the nacelles farther aft, ultimately to the hover position of 90 degrees. Nacelle position is moved in discrete steps, beginning at 70 degrees. A small amount of full aft nacelle position (95 degrees) was used for braking just before coming to a hover over the landing pad. Careful control of the aircraft flight condition as conveyed to the pilot by the flight director results in the concentration of approach noise in the immediate environs of the landing pad while minimizing noise along the approach track.

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Methods for Predicting Blade-Vortex Interaction Noise

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Rotor-vortex interactions have been the subject of many experimental, analytical, and computational studies. Most of this activity is motivated by the importance of blade–vortex interactions (BVIs) as a major source of rotorcraft noise and vibration problems. The conceptual simplicity of the problem has encouraged the development of numerous computational methods, ranging from simple, incompressible two-dimensional analyses to full three-dimensional Euler/Navier–Stokes computational fluid dynamics (CFD) codes. However, experimental data of comparable simplicity were unavailable because of the difficulty of generating sufficiently clean vortices in a wind tunnel environment, and also because of the difficulty of acquiring corresponding loading and acoustic data. These experimental problems have been largely solved by the rotor/vortex-generator approach originally employed by B. McCormick (Pennsylvania State University) and later developed into a full aeroacoustic test at Ames Research Center. The first figure shows the rotor and vortex generator in the Ames wind tunnel setup.

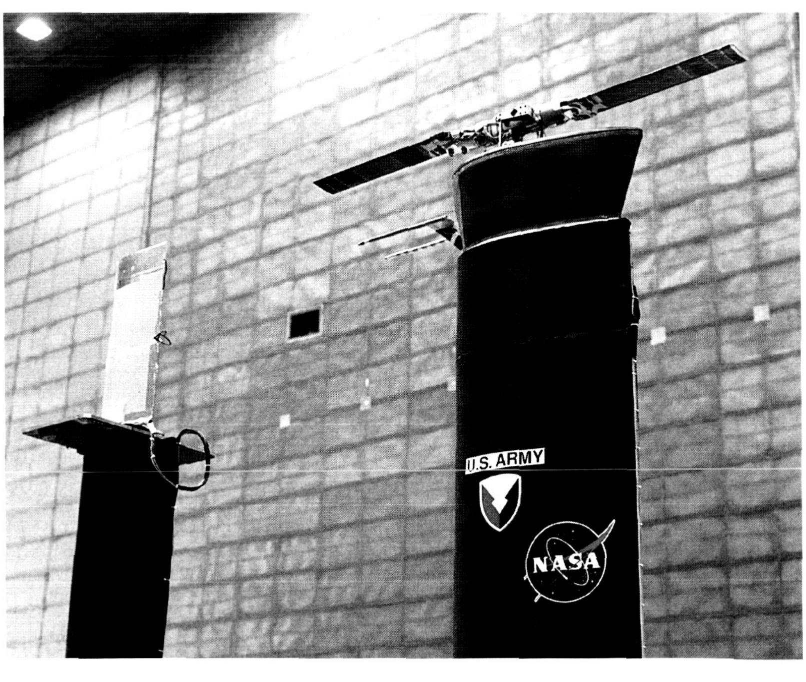

Fig. 1. Parallel BVI experiment in the Ames 80- by 120-Foot Wind Tunnel.